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SEDIMENT TRANSPORT IN THE EEL RIVER PLUME

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GOALS

The goals of this study are 1) to characterize the fluid and sediment transport processes within the Eel River plume and their influence on the delivery of sediment to flood deposits on the continental shelf; 2) to develop an advanced, hydrodynamic model to simulate the key physical mechanisms influencing sediment transport in the plume.

OBJECTIVES

1) to resolve the salinity and suspended sediment distributions within the river plume during flood events;

2) to document the forcing conditions for the plume, particularly the ambient shelf currents and water properties (in addition to the other relevant information such as river discharge, wind and wave data that is obtained from other sources);

3) to implement a three-dimensional model to simulate the observed plume structure and transport;

4) to use the model to analyze the physical mechanisms, particularly the sensitivity of the sediment delivery to variations in forcing parameters (e.g., freshwater discharge, winds, ambient along-shelf currents, mouth geometry).

APPROACH

1. Rapid Response Studies

The Rapid Response field program was designed to provide measurements of the plume structure during floods. This was accomplished with helicopter surveys of salinity, temperature, suspended sediment concentration and particle size during periods of high river discharge. The US Coast Guard base at Arcata provided the aircraft for the study. The surveys were triggered by river stage level, which for the 1996-1997 period was approximately 75,000 cfs. The January 1, 1997 flood greatly exceeded the threshold and provided an unprecedented set of measurements of a river plume during high discharge conditions. Surface drifters will be deployed within the plume as part of the Rapid Response study during the 1997-1998 flood season. They would have been deployed in 1997 if there had been significant events after the January 1 storm. In addition to the helicopter sampling, shipboard measurements will be attempted following events in the 1997-1998 period to obtain bottom boundary layer measurements of sediments.

2. Moored measurements

Moorings and bottom tripods were deployed in December, 1996 and will be deployed in November, 1997, to provide timeseries measurements of the flow, water properties and suspended sediment on the shelf. These include observations both within the plume and in the ambient shelf waters. The 1996-1997 measurements were located on the G-line approximately 4 km north of the mouth, but the 1997-1998 measurements will be located along the K-line, 10 km north of the mouth. Instruments will be located at the 20, 40 and 60-m isobaths. Based on the 1997 flood data, these will be located in a critical area with respect to the trapping of sediment in the inner shelf. The 20-m measurements will be within the plume during floods. There is significant risk of loss of the 20-m mooring, due to the extreme wave energy at that isobath.

3. Modeling

The Blumberg and Mellor model (known as ECOM-3D) or the Princeton Ocean Model) is being used to simulate the flow and sediment transport over the Eel River shelf during floods. The model is forced by observed winds, along-shelf currents and freshwater inflow. The domain is idealized to be rectangular, with a cross-shore variation of depth that is representative of the Eel River shelf. Although the model domain is

simplified, it appears to contain the important physical elements influencing the structure and transport of the plume.

WORK COMPLETED

The Rapid Response and moored measurements were extremely successful during the first year, owing to the huge discharge event on January 1, 1997. The only drawback was that the drifters were not ready for deployment at that time. The numerical model has been implemented, and a number of runs have been completed that have determined the critical parameters necessary to achieve realistic simulations of the observations. The necessary preparations have been made for the second year of sampling.

RESULTS

The results of the work to date have already been documented in several presentations and abstracts (see references below). The plume was found to be trapped against the coast, extending only 4 to 5 km offshore, and transporting water and sediment northward at speeds of up to 2 m/s. Based on the model studies, the rapid northward motion of the plume was caused by a combination of strong along-shelf wind forcing, strong ambient shelf currents, and a large component of along-coast momentum imparted by the geometry of the mouth. The sediment concentration within the plume decreased (relative to the freshwater content) by 20 to 50% in the first 15 km north of the mouth, due to settling of the coarse fraction as well as flocculation. The quantity of sediment that settled out of the plume was more than adequate to produce the 1997 flood deposit 97 the layer of new sediment that was observed on the shelf between the 50- and 90-m isobaths. The along-shelf position of the flood deposit was also consistent with the observed loss of sediment from the plume. However, the plume did not carry sediment seaward of the 40-m isobath, indicating that another mechanism transported the sediment from the inner shelf, where it fell out of the plume, to the mid-shelf mud deposit. The nature of this transport is the subject of feverish speculation, and if there are significant events in 1997-1998, the moored array will provide important insights into the transport mechanism.

IMPACT/APPLICATIONS

The field methodology of Rapid Response should have considerable application in a number of operational Navy and scientific settings. The three-dimensional model also has important applications in the scientific and operational realms.

TRANSITIONS

There has been a significant dialog between the PI and the STRATAFORM modelers to determine the effective means of incorporating these observational and modeling results into morphodynamic and stratigraphic models. This effort will ramp up in the next year.

RELATED PROJECTS

Related efforts include other plume modeling studies and sediment transport studies in estuaries.

REFERENCES

W.R. Geyer, D.J. Mondeel, P.S. Hill and T.G. Milligan: The Eel River plume during the 1997 flood: Freshwater and sediment transport. (Abstract to AGU Oceans 1998 Spring meeting.)